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ABSTRACT

The Janus ISP upgrade is being developed at LLNL to provide a high-energy (hundreds of Joules) short duration (0.5 to 200 ps) laser pulse with variable delay from a second high-energy (up to 1kJ) long duration (0.2 to 20 ns) laser pulse on target. A new target chamber will allow the angle between the long and short pulse beams to be varied from about 35° to near 180°. Commissioning of the system will begin in the summer of 2005.

SUMMARY

Janus is a high-energy two-beam Nd:glass laser with 15-cm clear aperture disk amplifiers as the output stage. Both beams are designed to reach 1 kJ of output energy at 1.05 μm wavelength with long pulse durations of several nanoseconds. We are in the process of adding chirped pulse amplification (CPA) capability to the west beam, which will enable generation of sub-picosecond pulses with energy up to 200 J, and as much as 500 J for pulse durations of several picoseconds.

To add short pulse capability to the west beam a new short pulse front-end laser system is under development. Pulses are generated in a commercial GLX-200 short pulse (~200-fs) oscillator made by Time Bandwidth Products, Inc. An Offner style pulse stretcher is used to increase the pulse duration to 4-ns with a 390-ps/nm chirp-parameter. A three stage Optical Parametric Chirped Pulse Amplifier (OPCPA) boosts the pulse's energy from 1 nJ to 40 mJ. The pump laser for our OPCPA stages is a custom designed injection seeded laser. Pump pulse generation begins with electro-optic modulation of a CW oscillator, followed by regenerative amplification in a 3-mm Nd:YLF rod, and a 4-pass amplifier with two 12.7-mm Nd:YLF rods up to 1.5 J of 1.05-μm output at 5Hz. A BBO crystal produces 0.8 J of 0.53-μm light to pump the OPAs.

The 40 mJ OPCPA output is injected into Nd:glass amplifiers including a 25-mm rod, two 50-mm rods, a double-pass 9.4-cm disk, a single pass 9.4-cm disk, and a 15-cm disk amplifier. Faraday rotators and Pockels Cells are used to protect the system from damage due to back reflections. A magnifying telescope increases the beam size to 25-cm and transports it to the vacuum compressor diffraction grating system.

The compressor is a two-pass two-grating system with a single flat end mirror reflecting the pulse for the second pass. Propagation is at a slight angle (~ 0.7°) to the horizontal to allow separation of the input and output beams near the vessel's input and output ports.

The diffraction gratings are 1780 l/mm, 40-cm by 80-cm aperture Multi-Layer Dielectric (MLD) gratings that are currently under development at LLNL (see presentations by J. A. Britten, and W. A. Molander, Wednesday morning session). These provide higher throughput and damage threshold than gold gratings and will be used for the first time in the Janus short pulse compressor. They are operated at a 73.5° angle of incidence.

An f/3 off-axis parabola focuses the short pulse beam in a new target chamber (TC). The TC also allows a high-energy (up to 1 kJ) long-pulse (0.2 to 20 ns) beam to be focused on the same or separate targets with variable (positive or negative) temporal delay. The angle between the short and long pulse beams can be varied in discreet positions from about 35° to near 180°. Both the compressor and target chamber are designed so as not to preclude the future addition of a second short pulse compressor and focusing system.

System performance was modeled using a 1-dimensional Franz-Nodvik propagation code for chirped pulses developed at LLNL by Al Erlandson, as shown in Figure 1. The MLD grating damage threshold was estimated as $\Phi_0\tau^{0.3}$ where Φ_0 = 1.2 J/cm^2 and τ is in ps, consistent with recent damage threshold measurements made at LLNL. The performance prediction shown in Figure 1 limits the allowable peak fluence to 66% of the damage threshold. The B-integral limit shown in Figure 1 is where the accumulated nonlinear phase retardation at the spatial and temporal peak of the pulse reaches 2 radians prior to compression. Peak power at the shortest pulse durations is expected to exceed 500-TW on target after system commissioning in the summer of 2005.

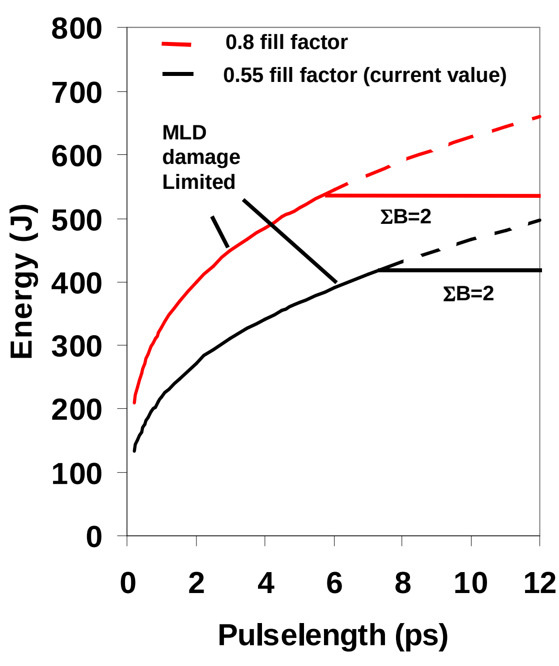

Figure 1. Short pulse energy on target is limited by damage threshold of the final MLD grating for short pulse durations < 6 ps, and by the accumulation of non-linear phase retardation (B-integral) for longer pulse durations.

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